//// active interfaces

Project 02 - Design

Architectural design strategies for renovation projects with BIPV optimizing self-consumption and self-sufficiency

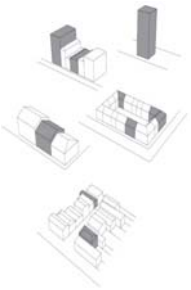
Sergi Aguacil | Laboratory of Architecture and Sustainable Technologies (EPFL)

2nd PhD Seminar | ACTIVE INTERFACES | Lausanne | 29.03.2017

70 NRP Energy Turnaround National Research Programme

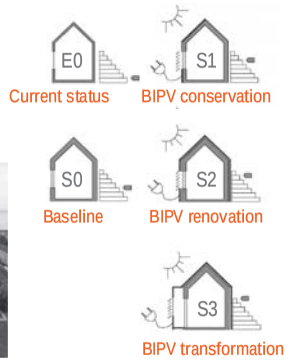
//// Research Methodology

Phase 1
Identification of archetypes (residential buildings)



Phase 2
Case study selection

Phase 3
Design strategies with BIPV solutions



Phase 4
Multi-criteria assessment

- Energy and emissions
- Life Cycle Analysis
- Photovoltaic installation
- Indoor comfort
- Cost-effectiveness

//// Agenda

- Research methodology
  - Presentation of the case studies - archetype 1 and 4
  - Design scenarios implementation - case studies
- Multi-criteria assessment
  - Indicators
  - Net energy balance
  - Annual irradiation threshold study
  - Optimization process
  - Results comparison
- Next step
  - Integration a PV battery storage system

//// Phase 2 | Case study selection | Residential buildings

Archetype 1

- Built in 1909
- 4 stories
- 8 apartments
- 603 m² floor area

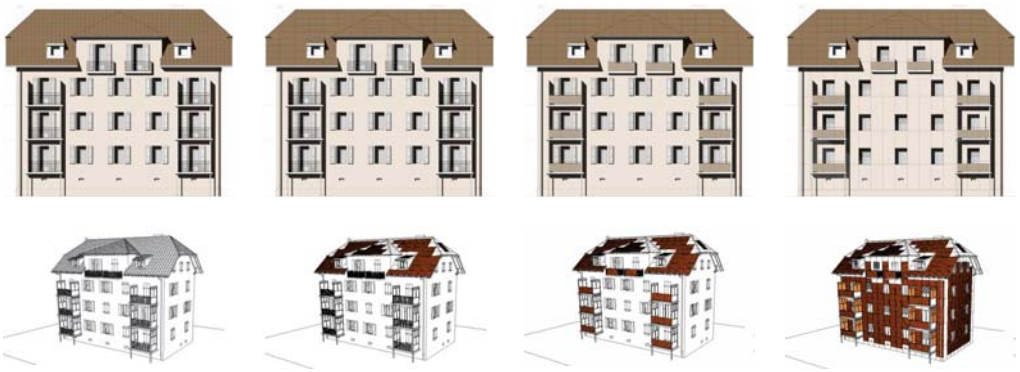
Archetype 4

- Built in 1972
- 11 stories
- 52 apartments
- 5,263 m² floor area

Level of protection: II - common
Heating system: central heating (Oil boiler)

///// Phase 3 | Design scenarios implementation | Potentially active surfaces

S0-Baseline | S1-Conservation | S2-Renovation | S3-Transformation



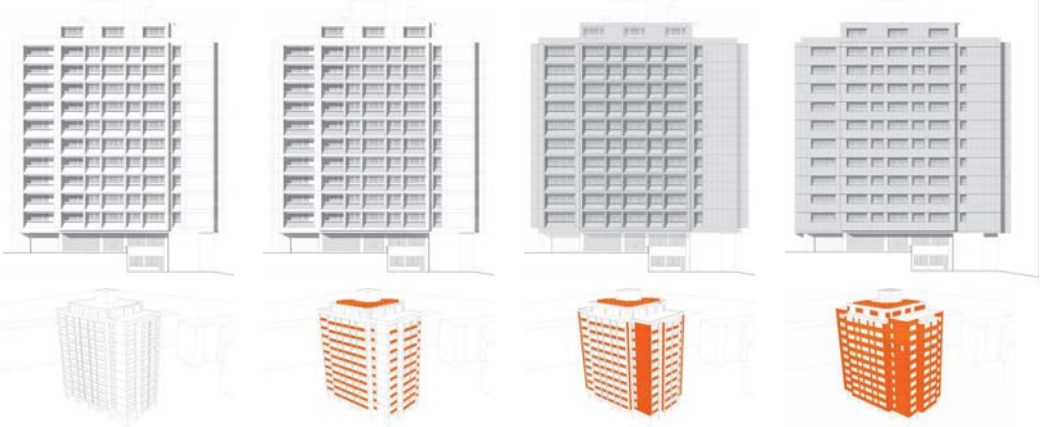
Archetype 1 | 1909

///// Phase 4 | Multi-criteria assessment | Indicators

Assessment indicator	*Unit*	*Method / tool used*	*3D modelling LoD*
1. Energy and emissions			
- Primary energy consumption	$kWh_{PE}/m^2.year$	Energy Plus	LOD3
- Equivalent GHG emissions	$CO_{2EQ}/m^2.year$	Energy Plus	LOD3
2. Photovoltaic installation			
- PV Generation	$kWh_{FE}/m^2.year$	Energy Plus	LOD3
- Self-consumption	%	-	-
- Self-sufficiency	%	-	-
3. LCA - Life Cycle Analysis			
- Embodied energy balance	$MJ/m^2.year$	ecoinvent + KBOB	-
- Global warming potential	$kgCO_2/m^2.year$	ecoinvent + KBOB	-
4. Indoor comfort			
- Spatial Daylight autonomy (300lux)	% of surface	Radiance / Daysim	LOD4
5. LCC - Life Cycle Cost			
- Accumulated cost	CHF	-	-
- Payback period	years	-	-

///// Phase 3 | Design scenarios implementation | Potentially active surfaces

S0-Baseline | S1-Conservation | S2-Renovation | S3-Transformation

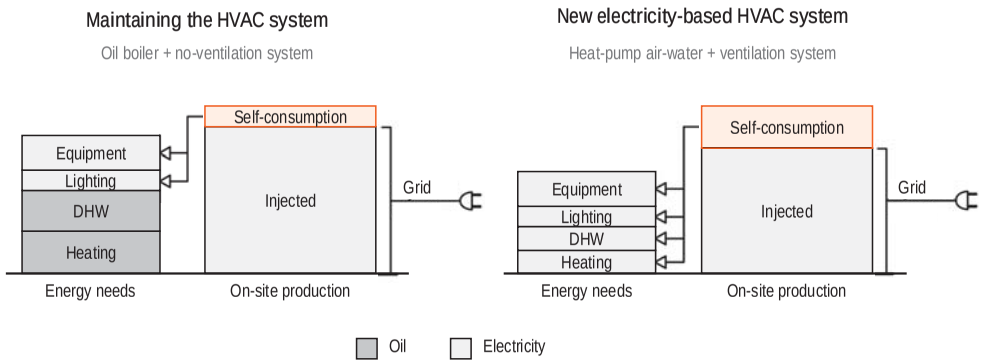


Archetype 4 | 1972

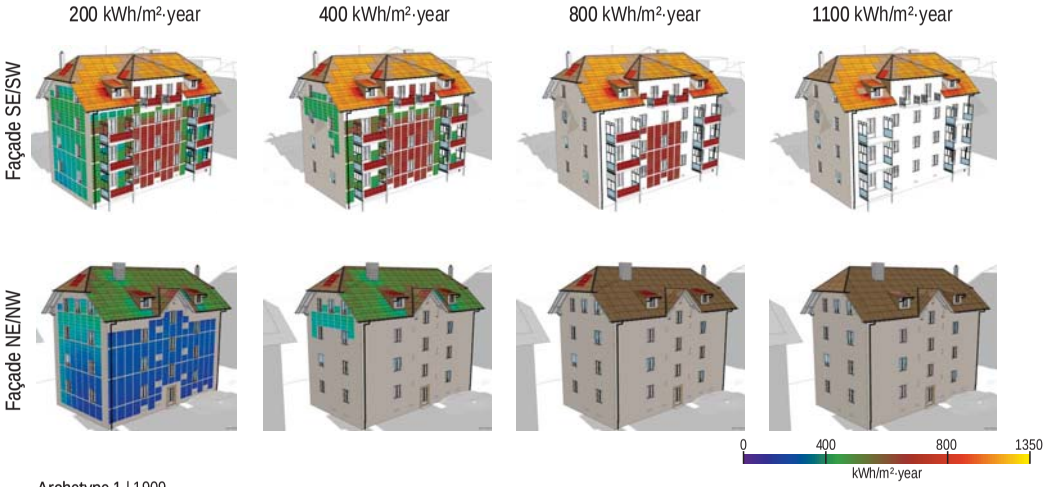
///// Phase 4 | Multi-criteria assessment | Indicators

Assessment indicator	*Unit*	*Method / tool used*	*3D modelling LoD*
1. Energy and emissions			
- Primary energy consumption	$kWh_{PE}/m^2.year$	Energy Plus	LOD3
- Equivalent GHG emissions	$CO_{2EQ}/m^2.year$	Energy Plus	LOD3
2. Photovoltaic installation			
- PV Generation	$kWh_{FE}/m^2.year$	Energy Plus	LOD3
- Self-consumption	%	-	-
- Self-sufficiency	%	-	-
3. LCA - Life Cycle Analysis			
- Embodied energy balance	$MJ/m^2.year$	ecoinvent + KBOB	-
- Global warming potential	$kgCO_2/m^2.year$	ecoinvent + KBOB	-
4. Indoor comfort			
- Spatial Daylight autonomy (300lux)	% of surface	Radiance / Daysim	LOD4
5. LCC - Life Cycle Cost			
- Accumulated cost	CHF	-	-
- Payback period	years	-	-

///// Phase 4 | Multi-criteria assessment | Net energy balance

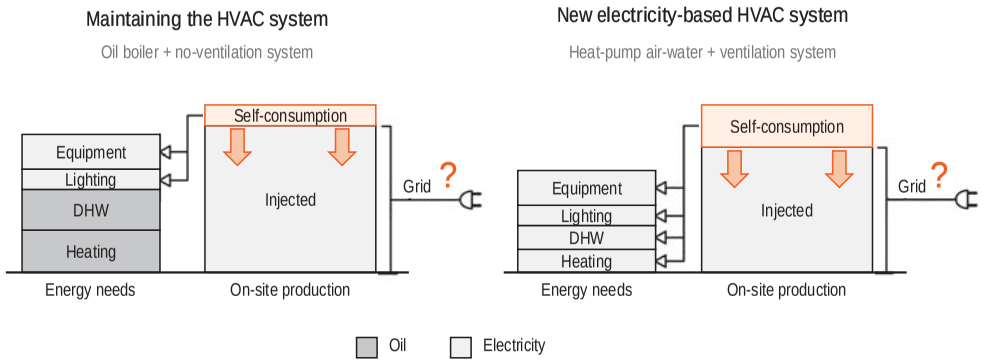


///// Phase 4 | Annual Irradiation threshold study | S3 - Transformation

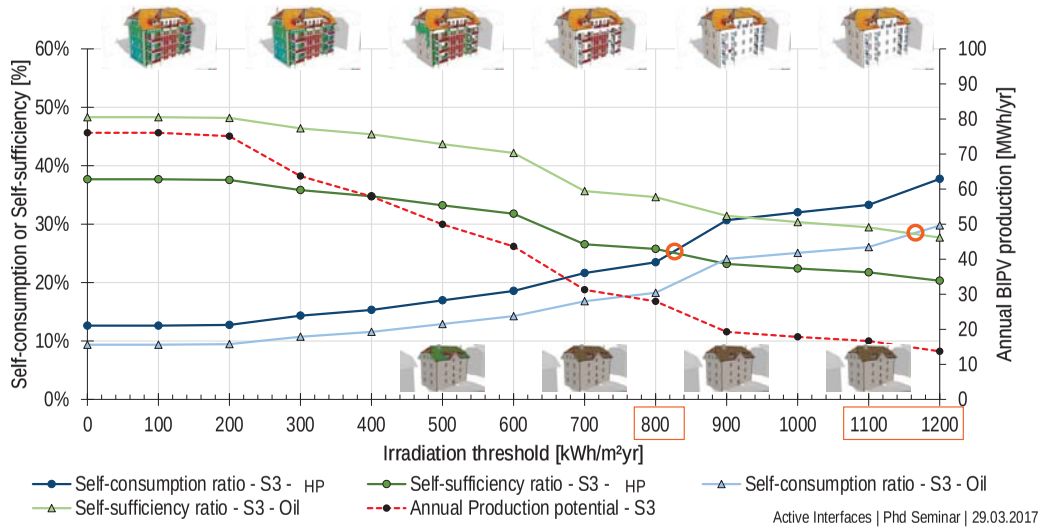


Archetype 1 | 1909

///// Phase 4 | Multi-criteria assessment | Net energy balance



///// Phase 4 | Optimization | S3 - Transformation



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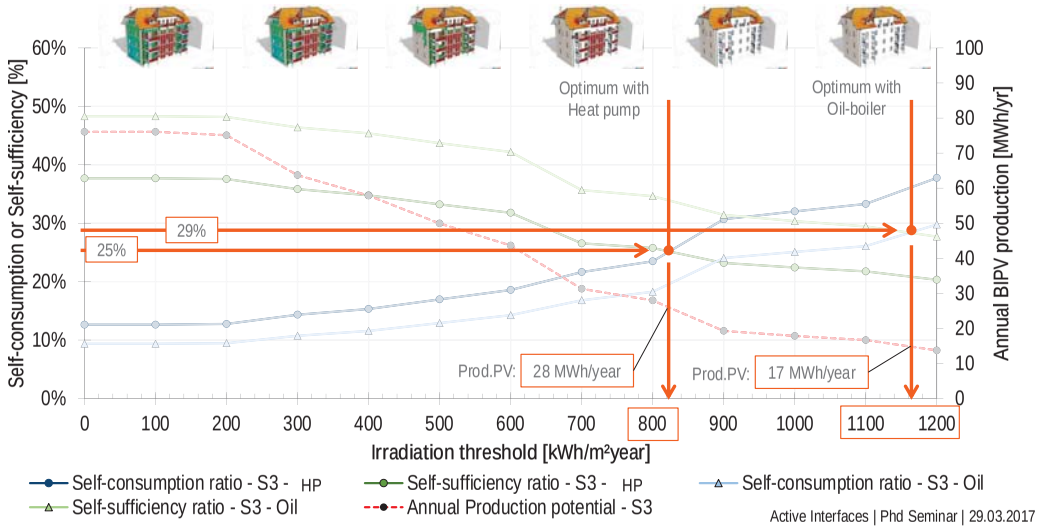

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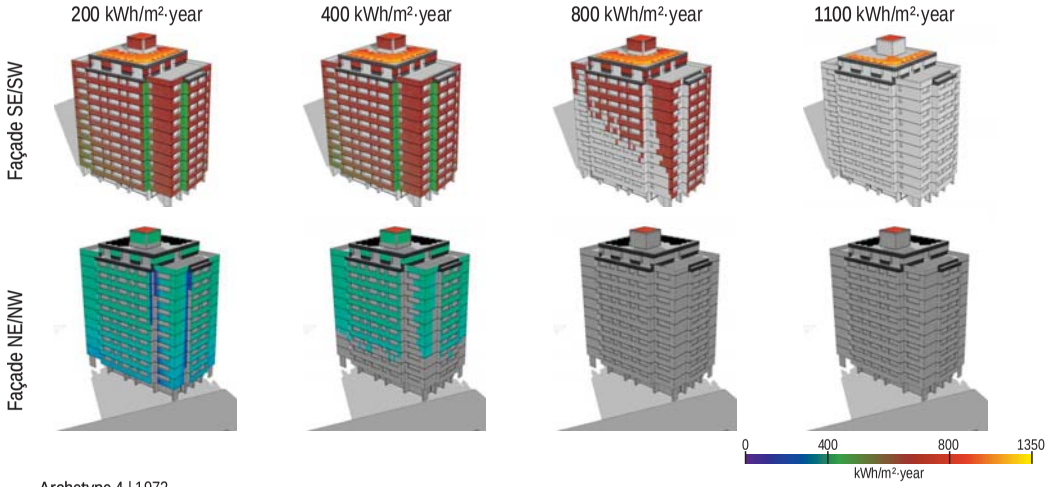
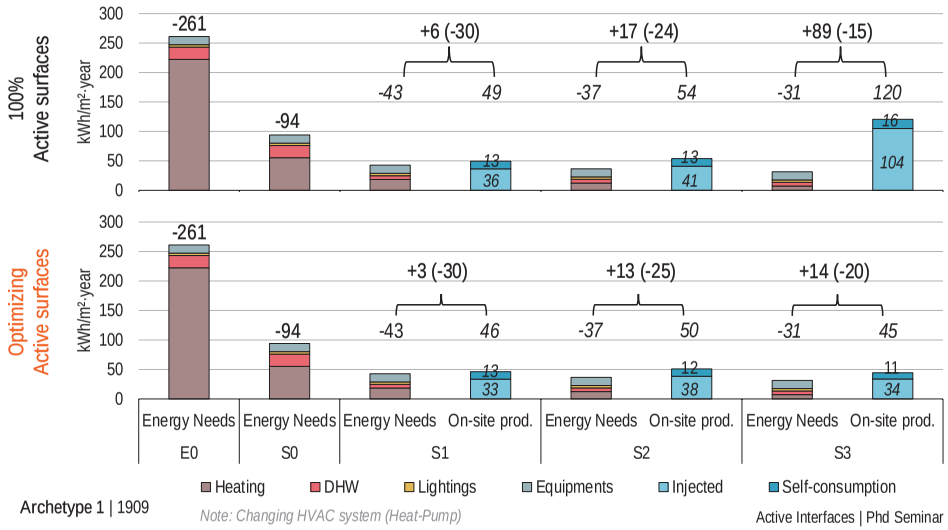


Archetype 4 | 1972

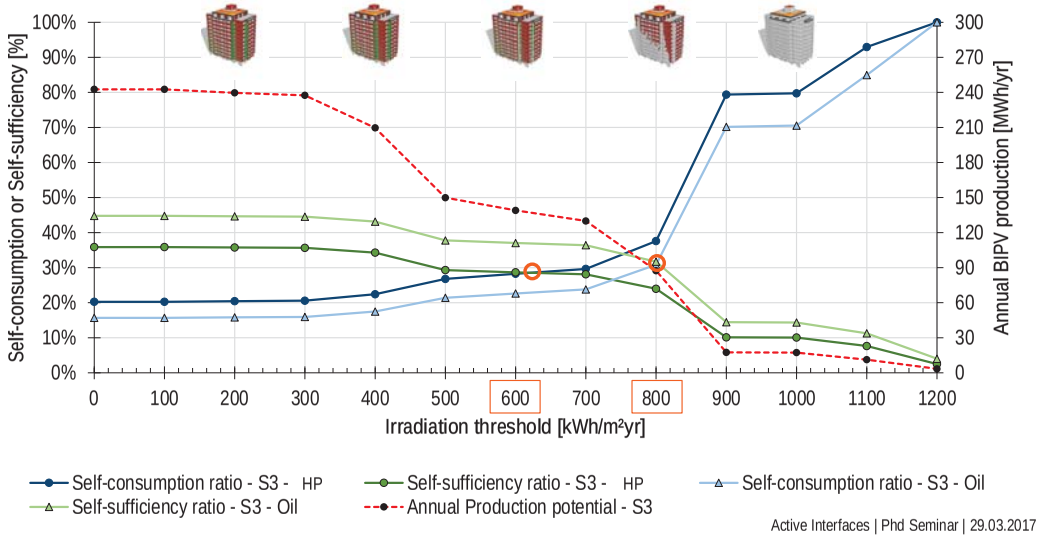
///// Phase 4 | Multi-criteria assessment | Net energy balance



Archetype 1 | 1909

Note: Changing HVAC system (Heat-Pump)

///// Phase 4 | Optimization | S3 - Transformation



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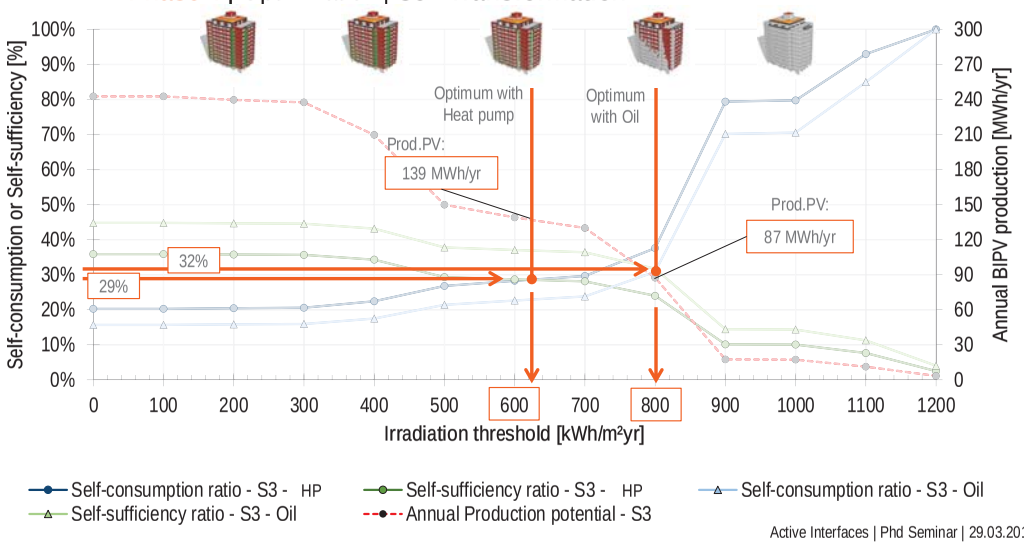

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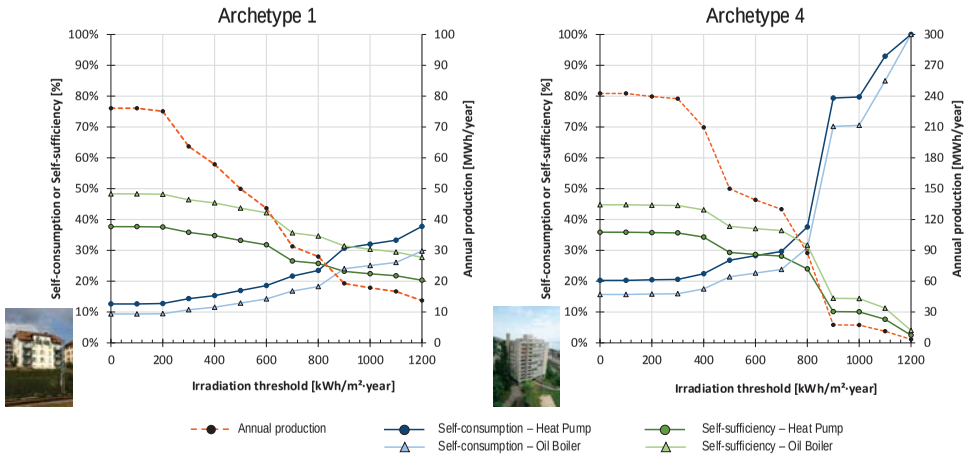

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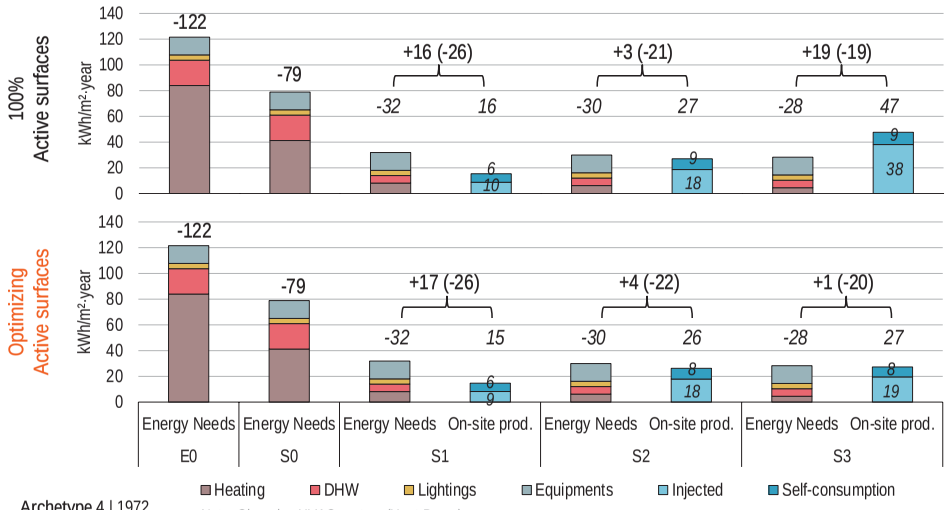


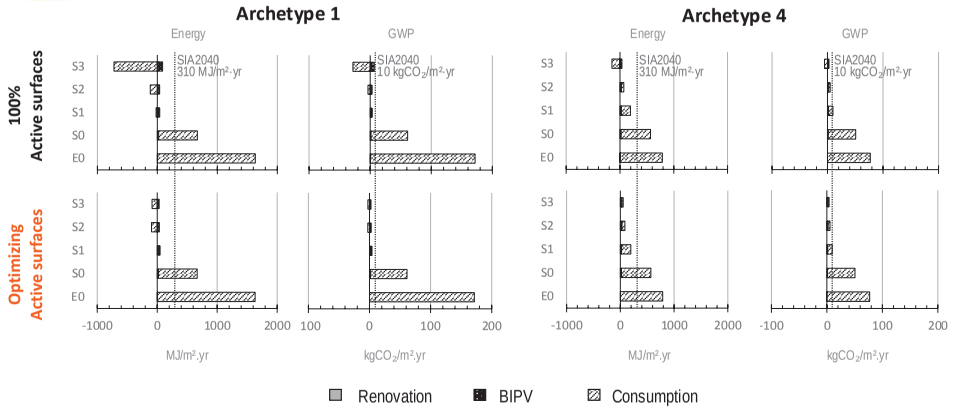
Archetype 4 | 1972

Note: Changing HVAC system (Heat-Pump)

///// Phase 4 | Multi-criteria assessment

LCA - Life Cycle Analysis

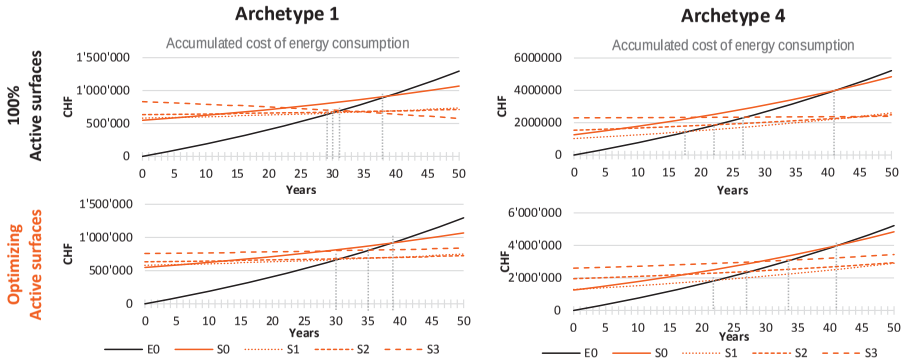
Passive and active strategies + Low-impact materials



Note: Changing HVAC system (Heat-Pump)

///// Phase 4 | Multi-criteria assessment

LCC - Life-cycle cost



Note: Changing HVAC system (Heat-Pump)

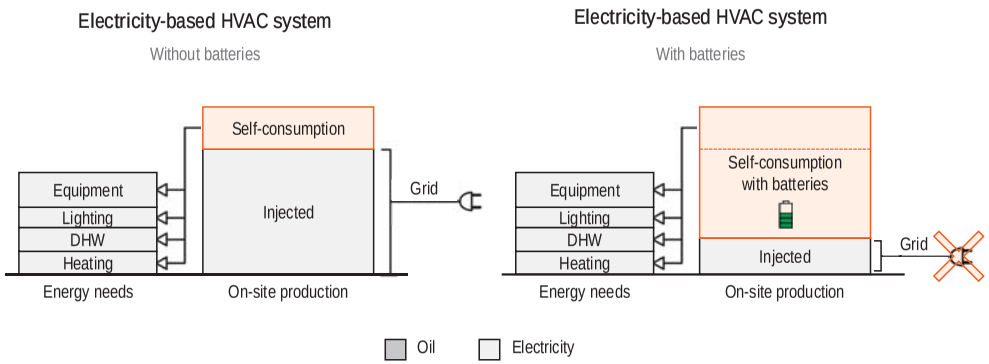
///// Next step | Integration a PV battery storage system

Batteries capacity			Annual results: Without batteries		With batteries
Average daily demand	→ 83 kWh	Self-consumption	26%	→	57%
Needed capacity	→ 172 kWh	Self-sufficiency	24%	→	53%
Number of batteries*	→ 15	Purchased electricity	5'216 CHF/year		3'214 CHF/year
		Batteries payback	--		5 years

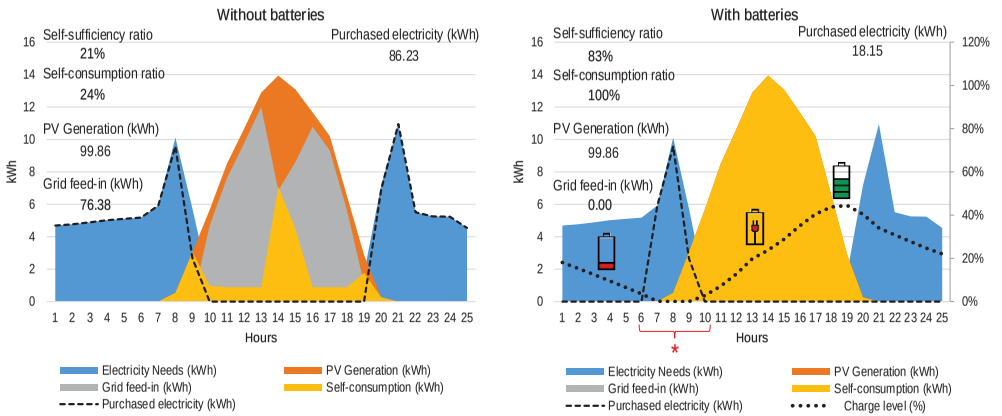
* Battery example: ROLLS 24V S480 480Ah C100

Archetype 1 | S1 - Conservation

///// Next step | Integration a PV battery storage system



///// Next step | Integration a PV battery storage system



* Backup system or grid consumption

Archetype 1 | S1 - Conservation

active interfaces

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